Evaluation and Comparison of Microphysical Algorithms in WRF-ARW Model Simulations of Atmospheric River Events Affecting the California Coast

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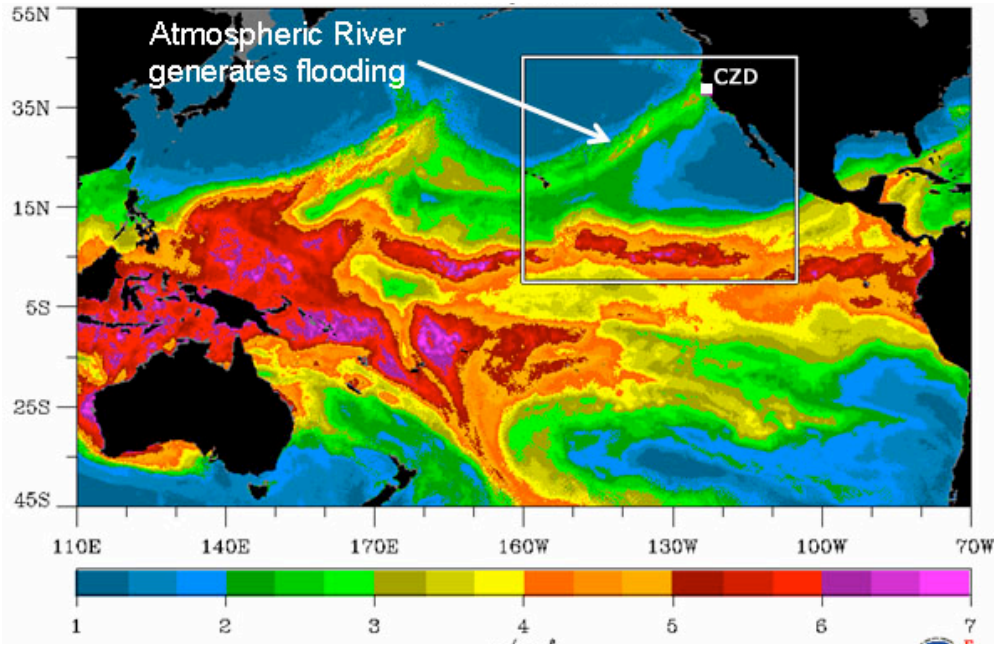
INTRODUCTION

• During the winter season significant precipitation events in California are often caused by land-falling “atmospheric rivers” associated with extra tropical cyclones in the Pacific.

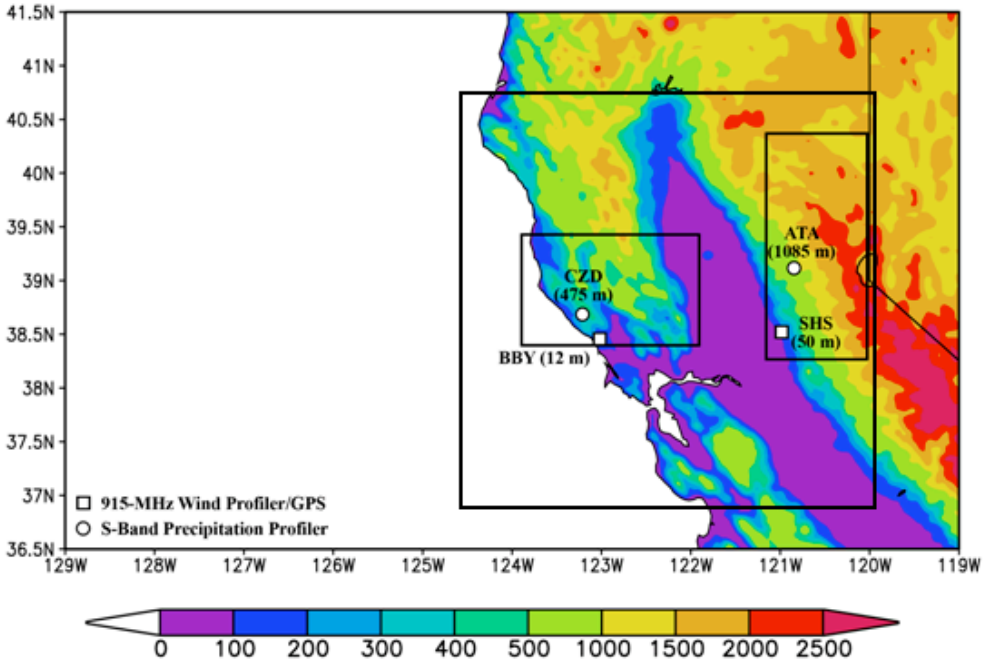
• Atmospheric rivers are elongated regions of high values of vertically integrated water vapor over the Pacific and Atlantic oceans that extend from the tropics and subtropics into the extratropics (Neiman et al. 2007, Bao et al. 2006, Ralph et al. 2004) and are readily identifiable using SSM/I.



The main goal of the present study was to evaluate performance of the Weather Research and Forecasting (WRF) ARW model using various microphysics in the case of events characterized by atmospheric river settings.

SIMULATIONS

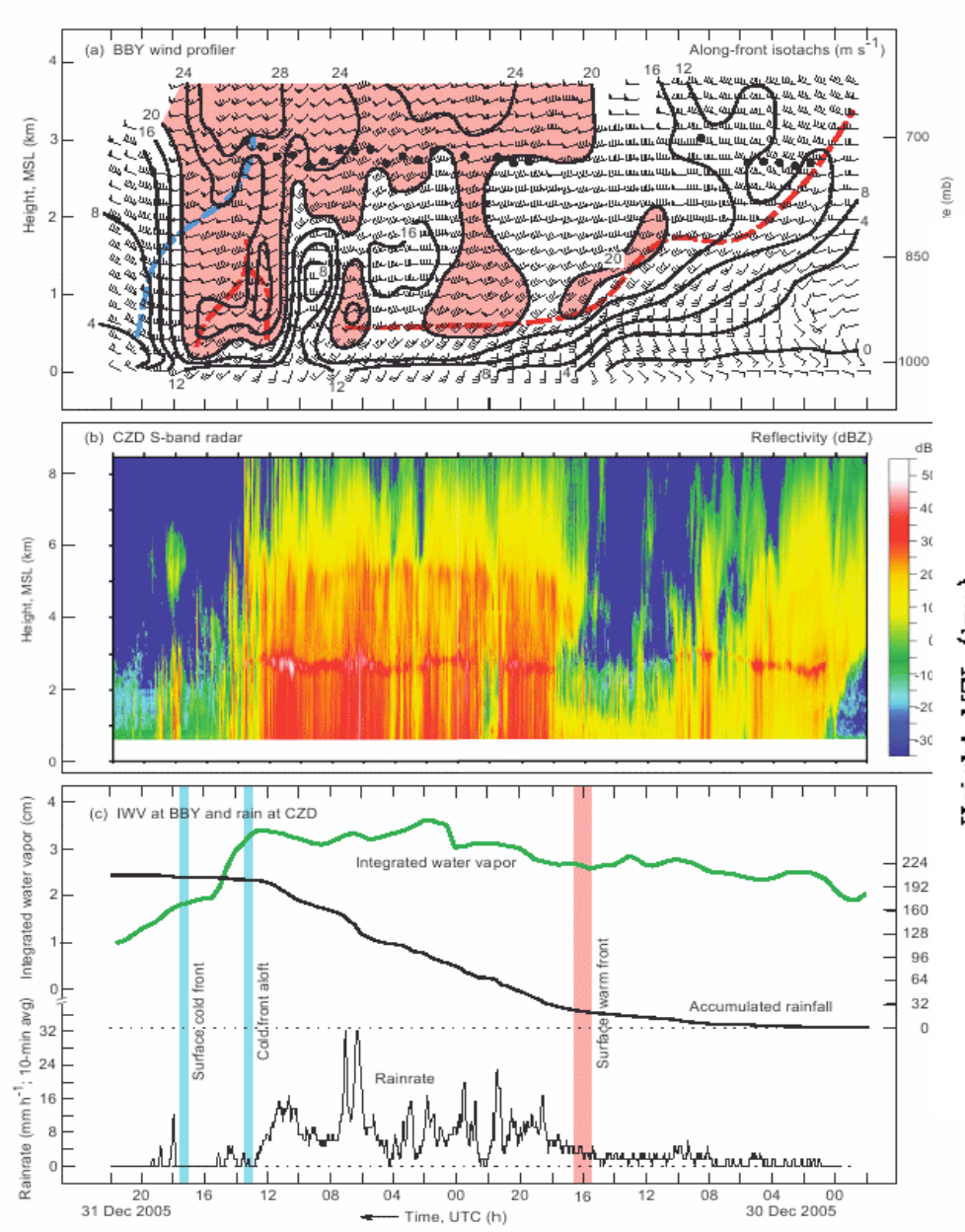
- 5 “atmospheric river” events
- 3km WRF-ARW
- 4 different Microphysics
  (Lin, WSM6, Thompson & Schultz)
- YSU PBL
- LAPS initialization
- 40km Eta LBC



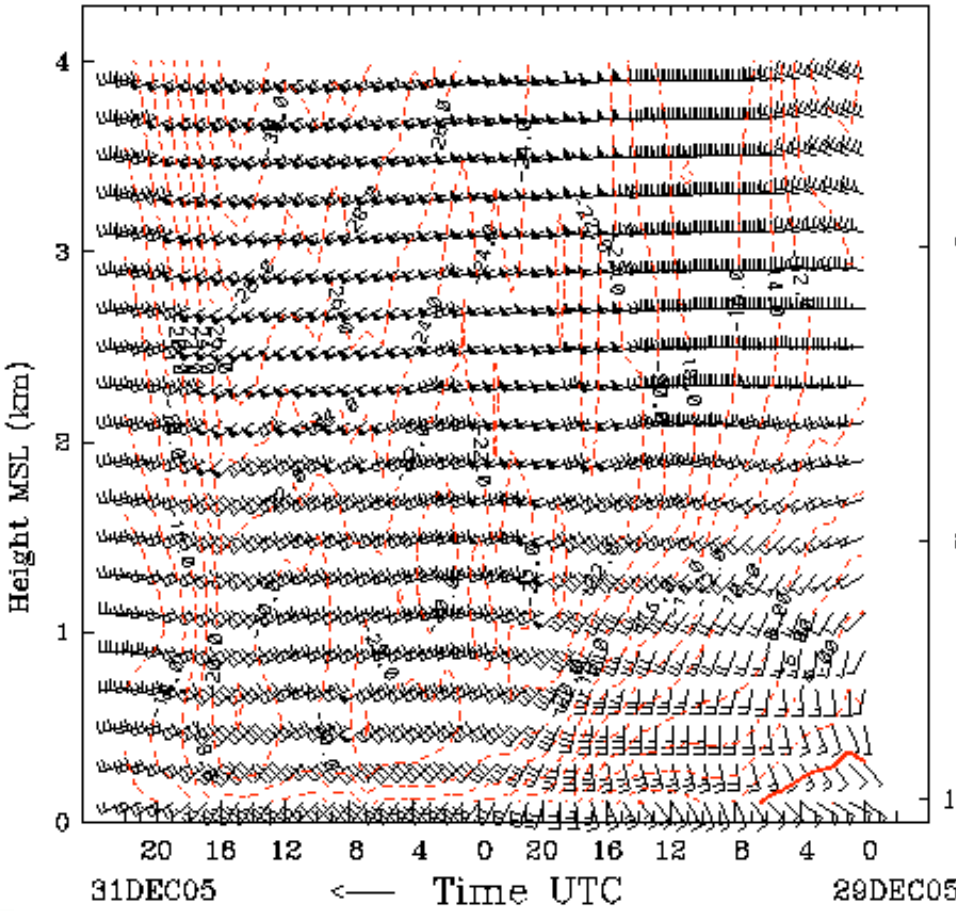
OBSERVATIONS

- Tipping-bucket rain gauges at Cazadero and Alta
  (CZD ~475m MSL and ATA ~1085m MSL)
- S-band vertically pointing radar (CZD and ATA)
- 915-MHz wind profiler at Bodega Bay and Sloughhouse
  (BBY ~12m MSL and SHS ~50m MSL)

EVALUATION OF SIMULATED MESOSCALE FEATURES

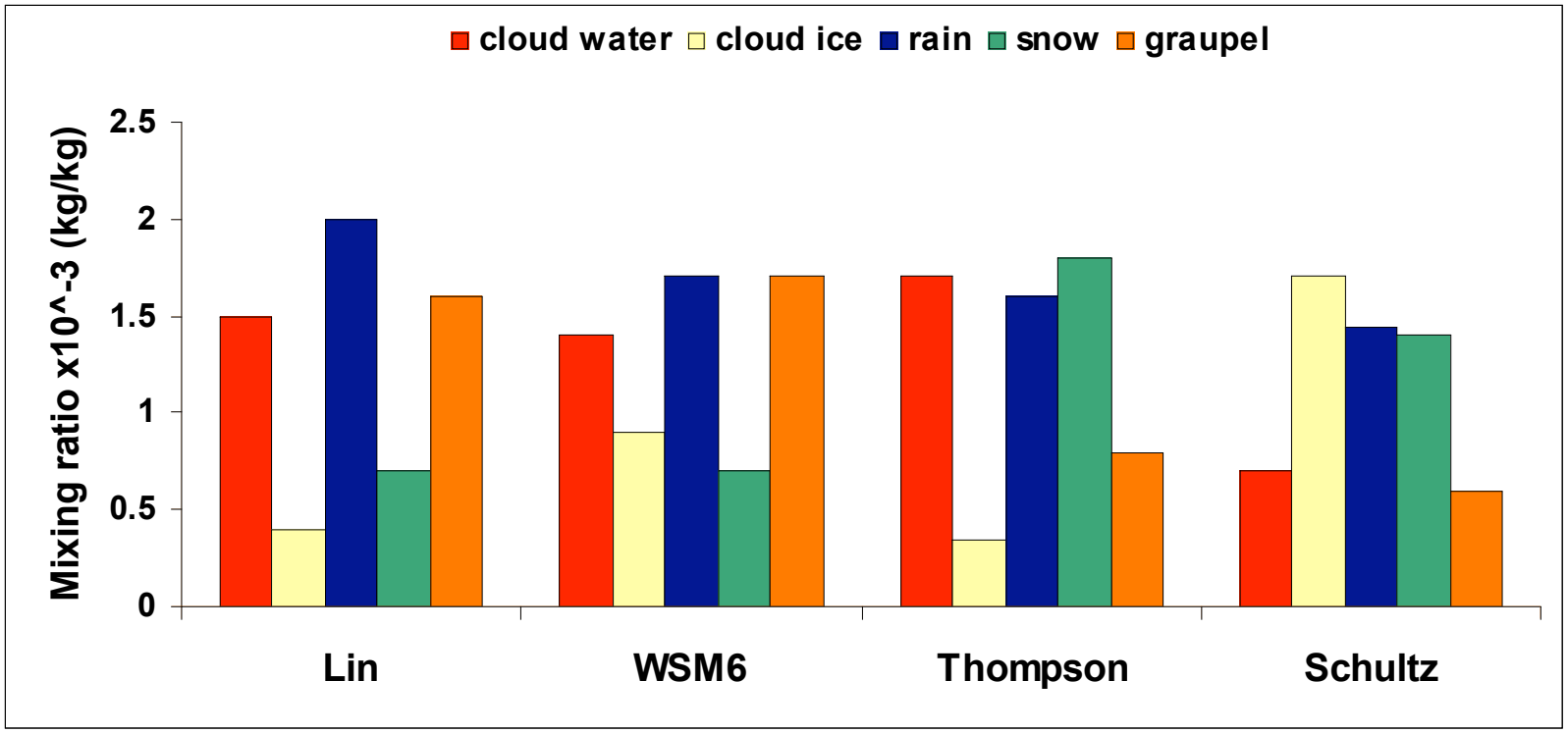


12302005 CZD
Wind profile simulation



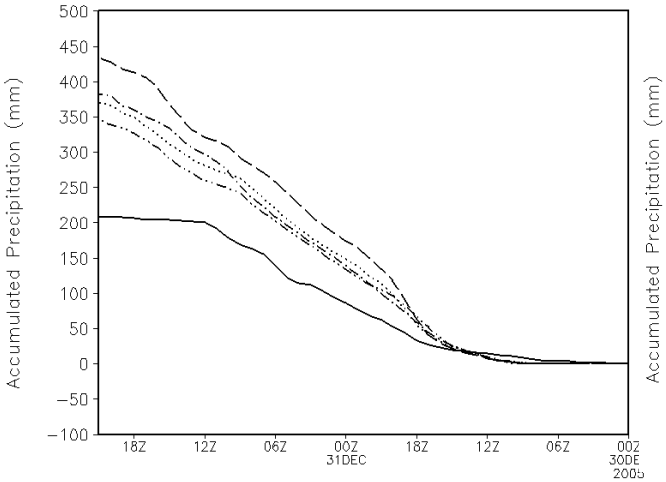
MICROPHYSICAL ASSPECTS: WATER SUBSTANCE PARTITION

6-hourly domain averages of water substance partitions for all 5 events

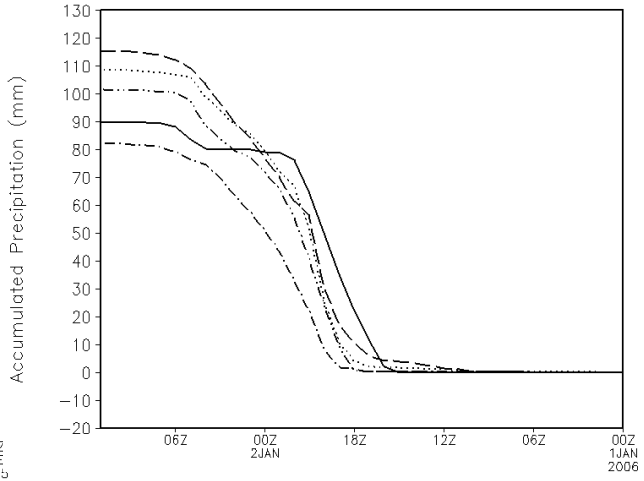


Observed and simulated precipitations at CZD for the 5 events

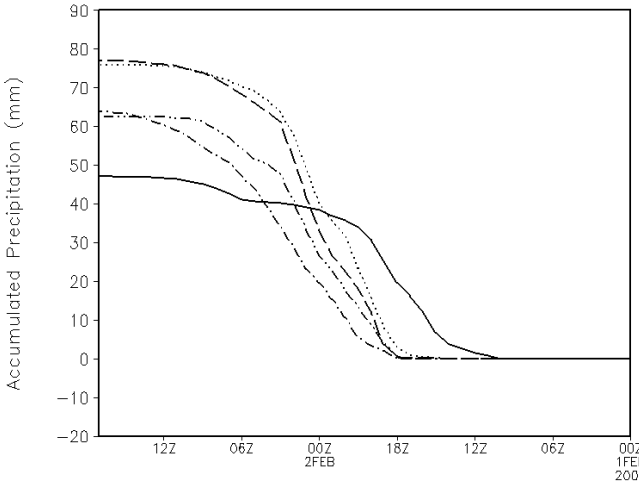
30122005 BB



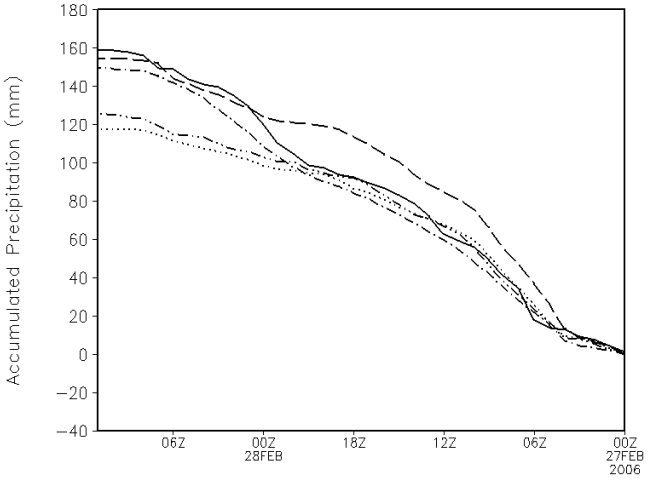
01012006 NBB



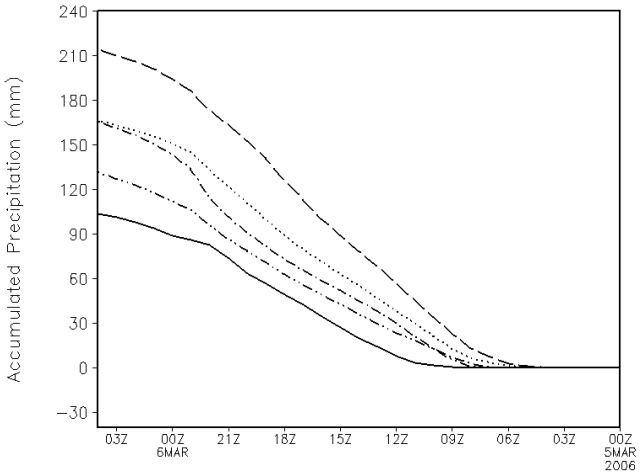
02012006 NBB



02272006 MIXED



03052006 BB



Legend

Observations ——————

Lin ----------

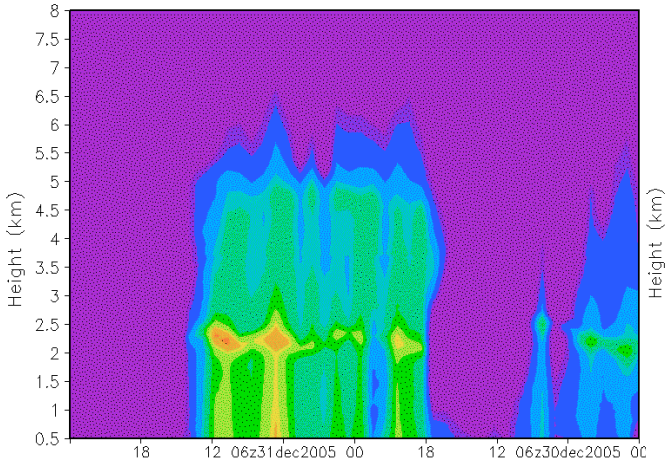
WSM6 ··········

Thompson -·-·-·-·-·-·-

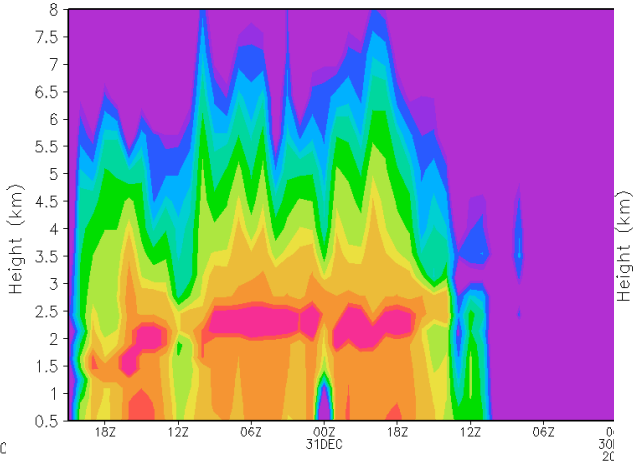
Schultz -·-·-·-·-·-·-

Hourly radar reflectivity (dBZ) at CZD for a 48-hour period starting at 00UTC 30 December 2005

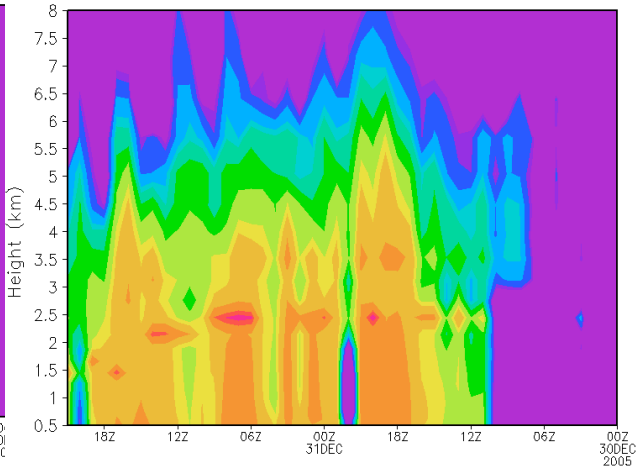
Observations



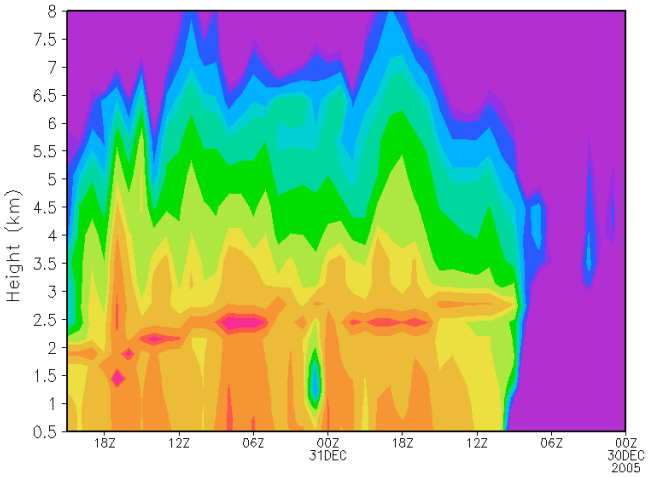
Lin



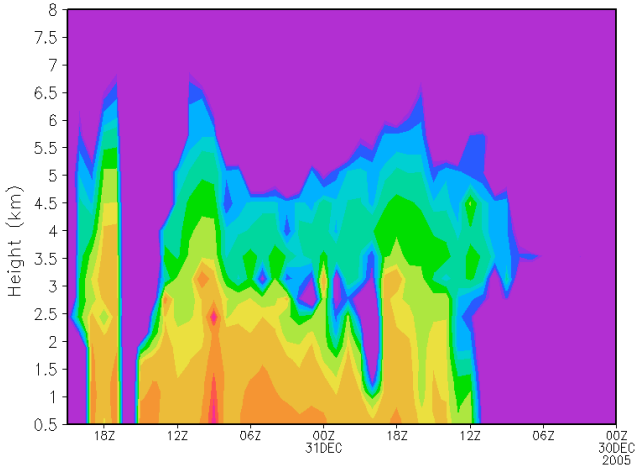
WSM6

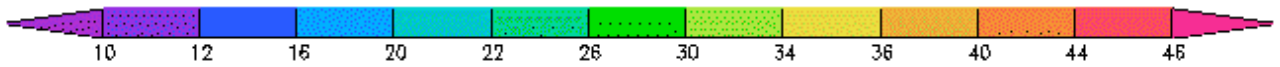


Thompson



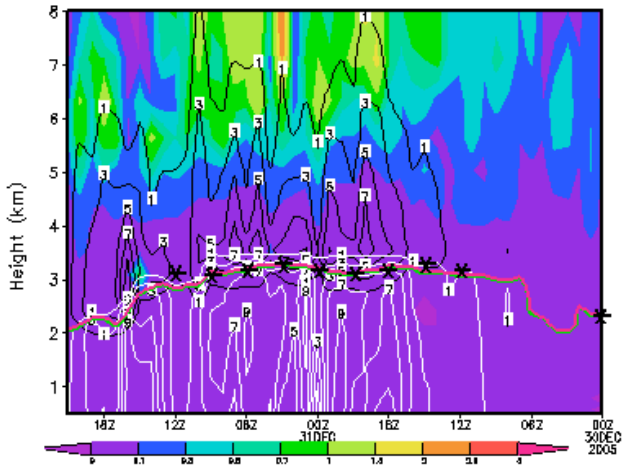
Schultz



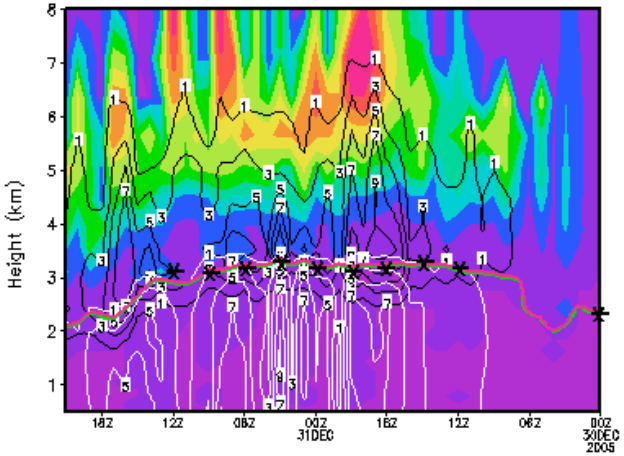


Snow (color shaded, see color bar), rain (white contours) and graupel (black contours) mixing ratios (kg/kg), and 0°C temperature (red) and wetbulb temperature (green) lines for the December 30, 2005 case at CZD

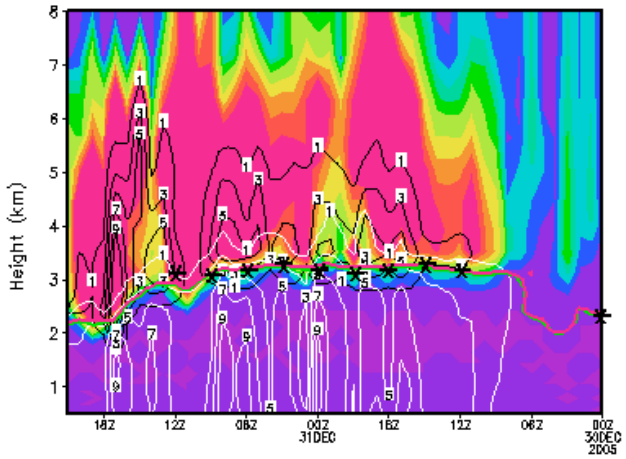
Lin



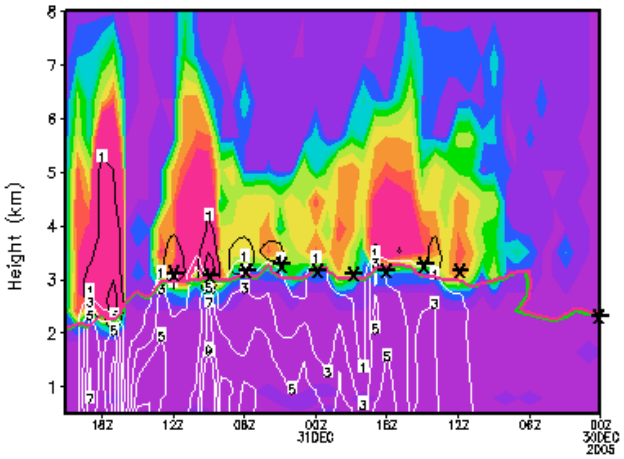
WSM6



Thompson

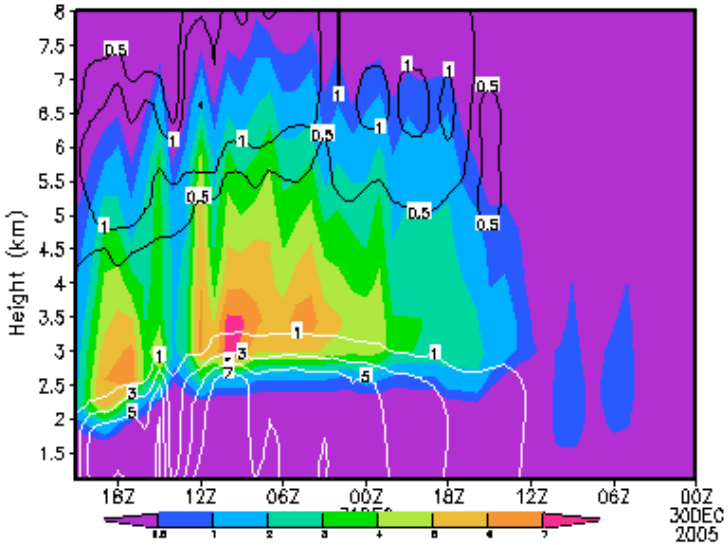


Schultz

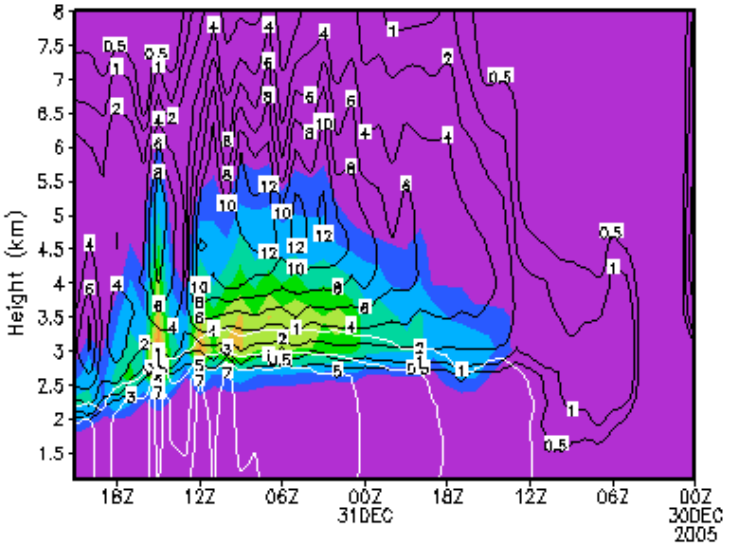


Time-height presentation of snow (black contours), graupel (color shaded), and rain (green contours) mixing ratios (kg/kg) for the ATA 30-31 December 2005

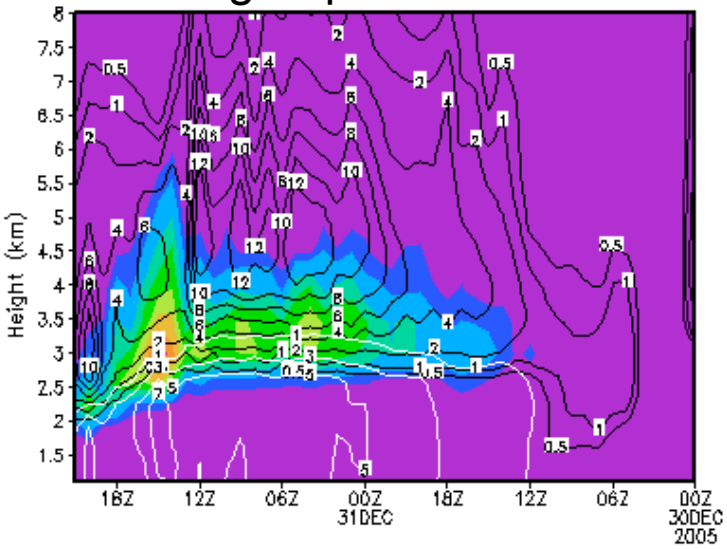
Lin Run



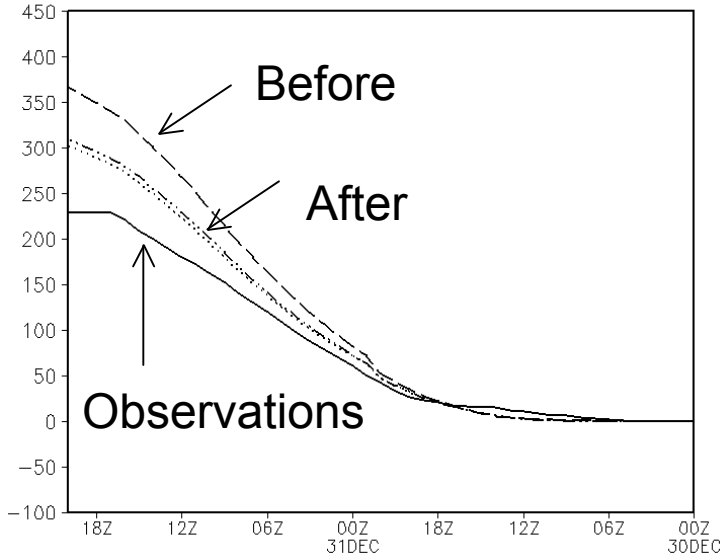
Snow Accretion set to 0



Threshold for Snow conversion to graupel lowered



Precip. before & after



FINDINGS

- Simulated precipitation amounts and synthetic reflectivity for atmospheric rivers events revealed a large sensitivity to the choice of microphysics.

- Simulated precipitations and reflectivity were influenced by the model's errors in the larger-scale flow.

- Differences in performance among various microphysical schemes were largely attributed to variations in the partitioning of water substance.

High-resolution QPF

Ensemble configurations:

4 models with multiple microphysics:

3 WRF-ARW (Ferrier, Thompson, Schultz) and 1 WRF-NMM (Ferrier)

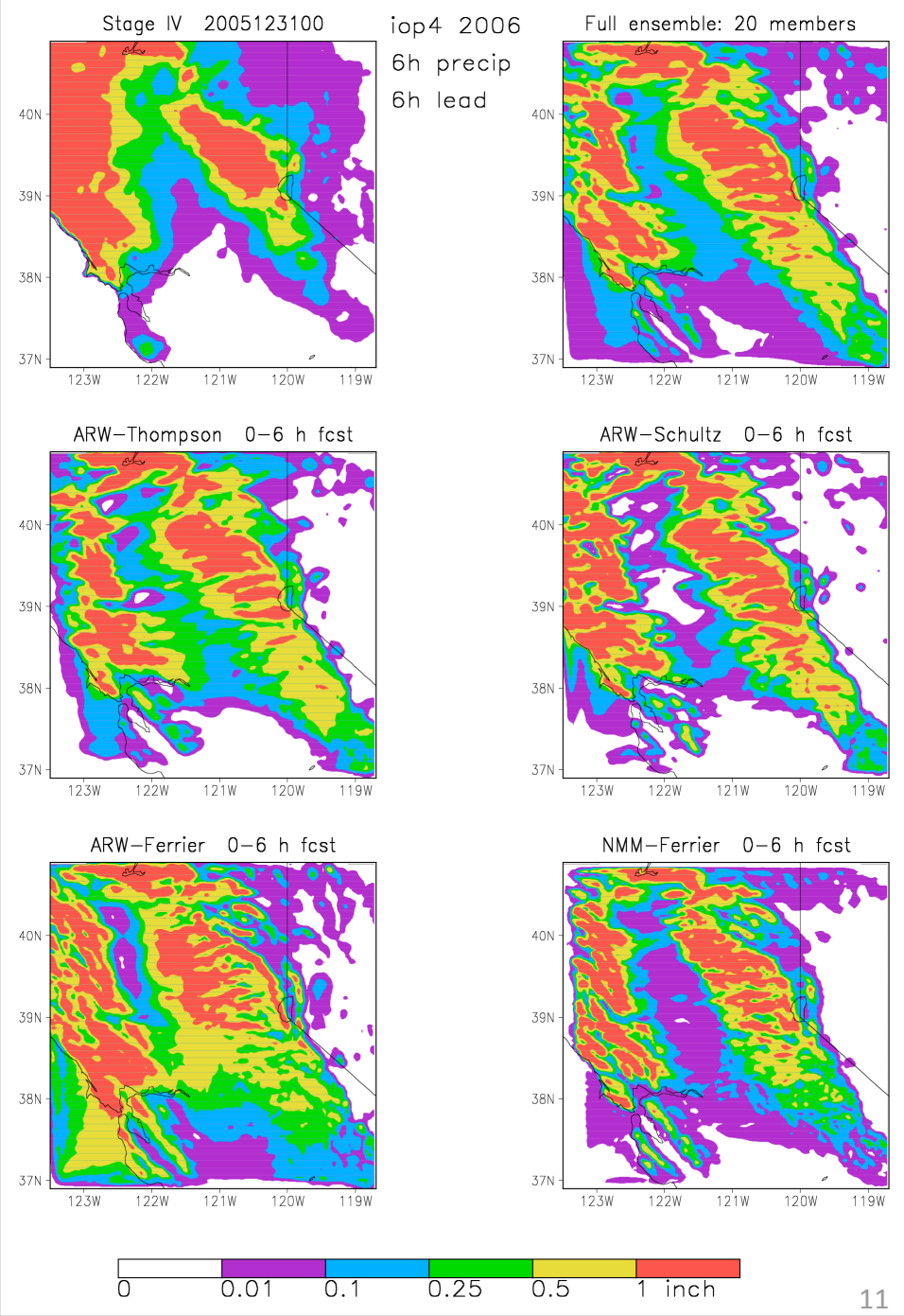
Initialized by the local analysis and prediction system (LAPS)

Forecasts out to 30 h at 3-km resolution, output 6-h QPF

150 x 150 grids, covering the ARB over Northern California

Stage IV QPE (~ 4 km)

Example: 6-h QPF, IOP4, December 2005



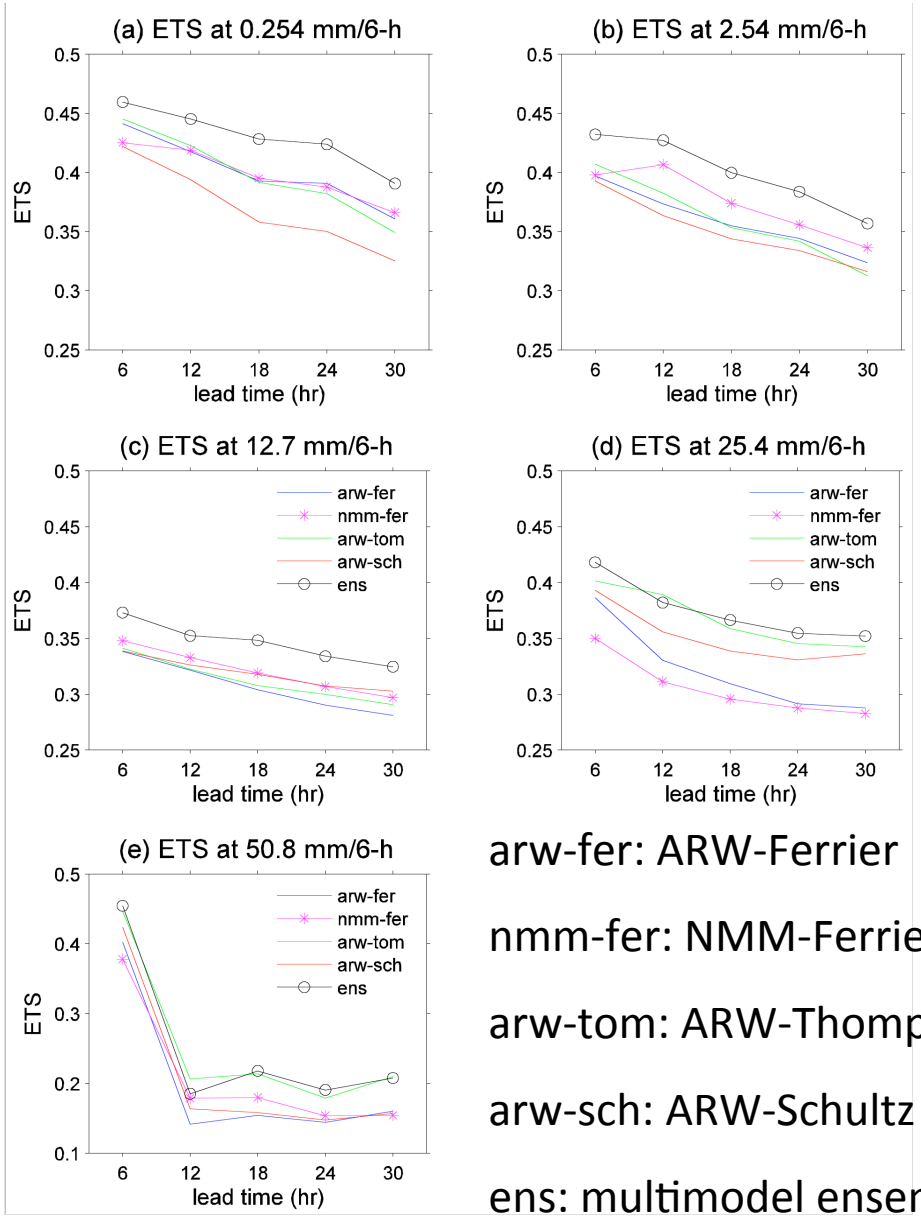
QPF

Forecast skill of 6-h QPF for different microphysics varies.

Equitable Skill scores (ETS) decrease with the forecast lead time and thresholds.

The performance of ensemble mean QPF is the best.

ETS for 11 IOPs during HMT-2006, HMT-2007



arw-fer: ARW-Ferrier

nmm-fer: NMM-Ferrier

arw-tom: ARW-Thompson

arw-sch: ARW-Schultz

ens: multimodel ensemble

Calibration of PQPF

Four rerun HMT-West-2006 cases:
IOP1, 4, 10, 12

Cross-validation over the ARB

Reliability curves are improved
for the thresholds 1-25 mm/6-h

Internal histograms:
Frequencies changed

Yuan et al. 2008, JHM